Bureau thermometer registered 110°, which was the highest reading ever recorded in 44 years. The ground thermometer corresponded exactly. The sky was mostly clear and the wind averaged 11.9 miles per hour.

The slightly higher day readings and lower night readings signified that the daily range must be proportionately greater at the ground. This varied from time to time. For the entire period the monthly mean daily ranges differed by 2.4°. The daily range varied from day to day, sometimes being close together and then again at wide variance. The greatest differences occurred during quiet spells when the radiation effect was greatest.

Actual practice in the United States Weather Bureau is to employ ground exposure at some 4,500 cooperative stations and at as many first-order stations as possible. Roof exposures are accepted only through necessity, never from choice.

The results of the comparative readings are summarized on a monthly basis in the table below.

TABLE 1.—*Summary of comparative readings, monthly means, and extremes*

Stations	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Monthly means, ground.	26.9	37.6	46.3	57.1	64.9	73.0	79.6	77.6	70.5	57.8	43.2	31.8	55.5
Monthly means, roof	26.6	37.0	45.0	56.0	64.4	72.2	79.0	77.3	69.8	57.9	42.6	30.8	54.9
Monthly means, maximum ground	36.9	48.7	58.9	68.8	76.5	83.9	91.2	89.2	81.8	69.4	54.0	42.0	66.8
Monthly means, maximum roof	35.6	46.7	56.1	66.1	74.8	82.0	89.3	88.0	80.0	68.4	52.3	39.9	64.9
Monthly means, minimum ground	16.9	26.5	33.7	45.5	53.3	62.1	68.0	65.7	59.2	46.1	32.3	21.6	44.2
Monthly means, minimum roof	17.6	27.4	34.0	45.9	53.9	62.4	68.7	66.6	59.6	47.4	32.9	21.7	44.8
Absolute maximum, ground	66	83	89	93	95	99	105	110	102	93	83	68	110
Absolute maximum, roof	68	83	88	93	96	100	104	110	101	93	84	68	110
Absolute minimum, ground	−19	−11	0	14	34	46	51	49	35	16	5	−9	−19
Absolute minimum, roof	−13	−7	4	17	35	49	52	52	38	16	10	−9	−13

FURTHER NOTES ON THE EFFECT OF WEATHER ON APPLE YIELDS

By W. A. MATTICE

[Weather Bureau, Washington, D. C.]

The effect of temperatures on apple yields was studied during 1927 by the author and the results published in the Monthly Weather Review.[1] The effect of precipitation, however, was not considered at that time as the purpose of the study was to substantiate the theory that spring temperatures were largely a determining factor in apple production. The precipitation by months was studied rather casually in a preliminary survey, but no definite relationship was established. However, a bulletin of the New York Agricultural Experiment Station by R. C. Collison and J. D. Harlan[2] was forwarded by the senior author for information as regards its conclusions. This publication contains the results of a rather exhaustive survey of an orchard of 50 Rome Beauty apple trees in New York. The conclusions drawn are that temperature departures from normal are not an important factor influencing yield, but that precipitation departures from normal are very important, especially those for the period from July 16 to September 1. It is also shown that the most critical period of these six weeks is that between July 31 and August 15. These conclusions, if they could be correctly applied to the entire State, would depreciate the spring temperature theory. In order to check these conclusions with State yields it was decided to collect rainfall data from the temperature stations and find such relationships as might exist.

The daily precipitation for three months, June to August, inclusive, was obtained and weekly amounts computed. Thus, the weekly periods covered the time from June 1 to August 30 and should show the critical period by the magnitude of the correlation coefficients.

The individual correlation coefficients for these 13 weeks are given below:

Week ending—	Correlation coefficient	Week ending—	Correlation coefficient
June 7	−0.14	July 26	0.07
June 14	.23	Aug. 2	−.06
June 21	.21	Aug. 9	−.05
June 28	−.18	Aug. 16	−.22
July 5	.36	Aug. 23	.20
July 12	−.29	Aug. 30	.14
July 19	.06		

The magnitude of the coefficients is very small, the largest being only 0.36, which is hardly large enough to consider. There is some significance, however, in the largest coefficients occurring in pairs, as it would appear from this 2-week periods are of more importance than single weeks. The coefficients of these 2-week periods with yield, by multiple correlation methods, were: June 7–21, 0.26; June 29–July 12, 0.59; August 9–23, 0.29. The increase of the coefficient for the weeks June 29–July 12, from 0.36 to 0.59, is rather striking. This is due to the fact that, while the two weeks have a positive and negative relationship with yields, the correlation between them is positive; thus the relation of both with yield is very much better in combination than separate.

The three 2-week periods were combined in a multiple correlation, giving a coefficient of 0.64, or only 5 points better than the coefficient of the weeks June 29–July 12. These six variables then were put into an equation in order to compute yields from them. The equation follows:

$$\overline{X}=1.14\ A-0.31\ B+3.16\ C-5.30\ D+0.95\ E+2.34\ F+8.22$$

The letters A, B, C, etc., refer to the single weeks, June 14, June 21, July 5, etc.

The computed yields from this equation gave a reduction of the standard deviation of 23 per cent. The reduc-

[1] Mattice, W. A. (1927): The Relation of Spring Temperatures to Apple Yields. MONTHLY WEATHER REVIEW, 55, 10: 456–459.

[2] Collison, R. C., and Harlan, J. D. (1927): Annual Variation in Apple Yields—A Possible Cause. Technical Bulletin No. 126, New York Agricultural Experiment Station, Geneva, April, 1927.

tion is rather small, but is valuable for forecasting purposes, as it enables one to come closer to actual yield than is possible using the average yield.

The use of these computed yields as a base for combination with the yields computed from the temperature data is following the method outlined by J. B. Kincer.[3] The yields computed from the rainfall data are called Yr and those from temperature Yt. Thus, the correlation coefficient, $rYtYrx=0.87$. This is an increase of 6 points over that obtained only from temperatures and gives a reduction of the standard deviation of 51 per cent, an increase of 10 per cent over that from temperatures alone.

It is not well to stop here, however, as some other combination of weeks might raise the coefficient. A small increase at these high values is very important, so it is worth while to try other combinations.

Thus, dropping the first week used, June 14, and combining the remaining weeks, gives a coefficient of 0.63, one point less than for the whole six weeks. It would appear that these weeks would not give such a high coefficient as the entire six, but the intercorrelation coefficient is only 0.39, against 0.46 for the whole period. The multiple coefficient is 0.88 against 0.87, or an increase of one point, a valuable increase, as there is a 2 per cent further reduction in standard deviation, bringing it to 53 per cent. The equation for computing yields from these latter variables was:

$$\overline{X}=0.58\ Yr+0.80\ Yt-3.93$$

Figure 1, shows the computed and actual yields for 1901–1925. The agreement is remarkably close, considering the range of the data, although a few years are still somewhat at variance with the actual yields.

[3] Kincer, J. B., and Mattice, W. A. (1928): Statistical Correlations of Weather Influence on Crop Yields. MONTHLY WEATHER REVIEW, 56, 2.

The standard deviation of computed from actual yields is 1.92, compared with the standard deviation of yield, 4.05; the reduction is 53 per cent, as before stated.

The period of two weeks ending with July 12 was also correlated with temperature and yield and produced a coefficient of 0.85, or only three points less than with the five periods and two less than with all six weeks. This, in itself indicates that the period from June 29–July 12 is a critical one for precipitation, although the other periods are of some slight importance.

Some other combinations were tried in order to exhaust all possibilities, but there was none that gave as satisfactory a result as that for five weeks.

The conclusions that can be drawn from the above statements are that temperatures are of major importance in the yield of apples, on a State basis, and that precipitation is only of secondary importance. These conclusions are possible only to State yields and can not be applied to single orchards, as demonstrated in the conclusions obtained by R. C. Collison.

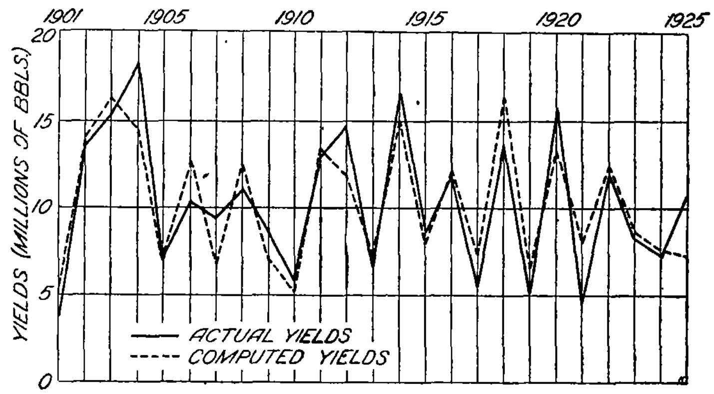

FIGURE. 1—Actual and computed yields of apples, New York State

EFFECT OF OZONE ON THE TEMPERATURE OF THE UPPER AIR

By EDWARD H. GOWAN

Two papers have been recently published by this author.[1]

The following abstracts are reprinted from Science Abstracts 32; 430 (1929) and 34: 58 (1931).

The illustrations are from the original papers.

The paper deals with the radiative equilibrium of the upper part of the atmosphere, taking into account the effects, with selective absorption, of water vapor and ozone. For material the author used (1) Abbot's curve for the distribution of energy in the solar spectrum from 0.4μ to 1.2μ and a black-body curve for 6,200° K. for 1.2μ to 6μ; (2) average radiation as for a black body at 260° K. from the earth and a moisture-laden atmosphere below 11 kilometers; (3) the amount of O_3 as constant and equal to a thickness of 3 millimeters at N. T. P. with a center of gravity at 30 to 40 kilometers; (4) a smooth average curve for absorption of O_3; (5) Fowle's figures for the absorption of H_2O vapor; and (6) saturation at 11 kilometers for 219° K. for H_2O vapour. Curves show the results obtained for temperature and height for (1) absorption and radiation due to H_2O vapor alone; (2) the observed amount of O_3 distributed as for O_2 down to 40 kilometers; and (3) an assumption of a change in distribution of O_3 to keep the temperature at 300° K. up to 150 kilometers. The effects on the temperature of (1) a different H_2O vapor distribution; (2) variation of absorption with temperature and pressure; and (3) a change in the center of gravity of the O_3 are discussed. The final temperature distribution arrived at agrees well with sound ranging and meteor observations.—*R. S. R.*

58. Effect of Ozone on the Temperature of the Upper Atmosphere, Part II, E. H. Gowan. Roy. Soc., Proc. 128, pp. 531–550, August 5, 1930. The method described in an earlier paper (see Abstract 430 (1929) is rendered more easy of solution by certain assumptions and allowance is made for diffusion of radiation from the earth. Preliminary estimates of the rate of cooling of the upper layers of the stratosphere and consideration of independent observational evidence of meteors lead to the belief that mixing of the constituents is general far above the tropopause. The radiation from the stratosphere must then be less and since the absorption of solar energy is the same, higher temperatures result. The maximum temperature attainable is investigated, this being governed by the rate of thermal decomposition of ozone and the rate at which ozone is formed in the atmosphere. The assumption of radiative equilibrium is reexamined in relation to convection being sufficient to insure mixing and the idea is retained. The effect of water vapor distributions for (*a*) no convection and gases in gravitational equilibrium, and (*b*) enough convection to give a constant composition is illustrated by calculations for varying conditions. The effects of different distributions and amounts of ozone and different zenithal angles of the sun are similarly treated. It is concluded that plausible distributions of ozone and water vapor provide the basis for a quantitative explanation of sound wave and meteor phenomena.—*R. S. R.*

[1] Proc. Roy. Soc. London A 120:655 (1928) and A 128:531 (1930), the second paper being an extension of the first.